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ABSTRACT

An evaluation is provided of study results involving 1,863 professors from five doctoral universities concerning their attitudes towards the costs and rewards that are perceived to exist when collaborating with external funding sources. The study attempts to confirm two hypotheses: first, researchers who are highly dependent on external funding sources will tend to overstate rewards and understate costs associated with collaboration with external organizations more than researchers with low dependency; and second, when facing high levels of dependency on external funding sources, university researchers who rely on private industry support will tend to overstate rewards and understate costs from collaboration with industrial corporations compared to their colleagues who are supported by federal agencies only, or by private non-profit foundations only. Analysis of the results of the responses is made through three theoretical concepts: (1) the measurement of dependency of individuals on external support, (2) researchers' perceptions of costs, and (3) researchers' perceptions of rewards. Implications arising from the results of the survey are discussed from the points of view of the funding sources, the university, and the academic researchers in engineering and bioscience. Contains 8 references. (GLR)

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HOW UNIVERSITY PROFESSORS PERCEIVE THE PROFITS ASSOCIATED WITH COLLABORATION WITH EXTERNAL FUNDING SOURCES

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Introduction

University professors' perceptions of the profits associated with the collaboration with funding sources do not exit in a vacuum. The perceptions are affected by the researchers' level of dependency on external support. It is assumed that individuals who are highly dependent on external sources will be affected by different factors when evaluating profits (specifically, costs and rewards), than will their colleagues who maintain a low level of dependency on external sources.

Individuals who maintain high levels of dependency on external sources are perceived to face harsh survival problems. Under these conditions, I predicted that the level of dependency on external support would affect the perceptions of individuals of the costs and rewards associated with cooperating with funding sources. It was hypothesized that when university researchers face a high level of dependency on external support, they will tend to overstate rewards and understate costs associated with collaboration with external funding organizations.

External funding sources refer to sources such as the federal government, state/local governments, private non-profit foundations, and industrial corporations. The literature on university-industry research partnerships has pointed out a number of disadvantages associated with the collaboration of university researchers and commercial organizations. More disadvantages were found to be associated with the collaboration with commercial organizations than with the collaboration with non-commercial ones. This finding has resulted in a negative image among academics in particular, and for the public in general, about the collaboration of university researchers and private corporations. Whether or not this image is correct, I predicted in the second hypothesis that university researchers funded by private industry will tend to shield themselves from these negative connotations by overstating rewards (i.e.,

indicating more rewards, on the average, than their colleagues who are not funded by private industry), and understating costs (i.e., indicating less costs, on the average, than researchers who are not supported by commercial organizations).

Policy-makers at both funding organizations and academic institutions need to know the kind of rewards which attract researchers, and the costs which antagonize them. University officials need to recognize the costs paid by professors for collaborating with funding sources. There seems to be a conflict between the norms of academic research and those of commercial organizations. For example, the sponsor's demand for proprietary knowledge conflicts with the academic value of free dissemination of knowledge. Issues of this kind need to be addressed and resolved before relationships are expanded, so that the price paid for establishing such relations will not exceed the benefits.

The Relationship Between Dependency and Perceived Costs and Rewards

Individuals will enter into a transaction when the perceived rewards exceed the perceived costs associated with the transaction (Homans, 1961). But what are the conditions under which this statement will be true? Is the equation "profits equals rewards minus costs" independent of external factors? What are the conditions under which this equation will not guide individuals facing a choice situation?

One such condition is the dependency of an individual on external sources. One's dependency on external organizations for acquiring needed resources might affect one's perceptions of the rewards and costs associated with the dependency, in such a way that highly dependent researchers will be inclined to understate the costs attached to the exchange relationship and overstate the

rewards. Resource dependence theory will be used in this study at the individual level of analysis. Rather than looking at the organizational level, (e.g., Pfeffer and Salancik, 1978), I will investigate the individuals' perceptions regarding research support coming from external sources. A previous study using resource dependence theory at the individual level of analysis was conducted by Shenhav (1985).

To understand how people perceive profits, I will use Homans' perspective of rewards and costs. This concept will be related to dependency of individuals on external organizations. Based on resource dependence theory and Homans' perspective of rewards and costs associated with exchange relationships, I formulate the first general hypothesis:

H_1: Researchers who are highly dependent on external funding sources will tend to overstate rewards and understate costs associated with collaboration with the external organizations more than researchers with low dependency.

Relationship Between Dependency, Perceived Rewards and Costs, and Type of Funding Sponsor

The second hypothesis is related to the first one, but adds another dimension--namely, the type of sponsor. Literature on university-industry research relationships in the engineering and bioscience fields has pointed to a number of factors that impose constraints on the university researchers' work (e.g., Bok, 1981; Brown, 1985; Barber, 1985; Blumental et al., 1986; and National Commission on Research, 1980.) As a result of these restrictions, members of the scientific community in the above academic disciplines have developed, whether correctly or incorrectly, some reservations regarding collaboration with private corporations. Thus, research partnerships between university and private industry have acquired a negative connotation, as if

accepting money from industry became somehow inconsistent with academic values.[1] If industrial support is only a small part of the researchers' total research funds, then they will be less rationalistic or dissonant about their collaboration with this sponsor than if they were supported solely (or mainly) by industry. Therefore, I formulate the second hypothesis as follows:

H_2: When facing high levels of dependency on external funding sources, university researchers who rely only on private industry support will tend to overstate rewards and understate costs from collaboration with industrial corporations compared to their colleagues who are supported by federal agencies only, or by private non-profit foundations only.

People who are highly dependent on external support are expected to perceive differently the costs and rewards because of the necessity to rationalize their actions, and their choice of sponsor. But, people who are "free" from dependence (or maintain a low level of dependency on external sources) are expected to adopt a more calculated view. They are assumed to justify their choice of the preferred sponsor without psychological and social pressures.

Operationalization of the Theoretical Concepts

Three theoretical concepts will be operationalized in this study: dependency of individuals on external support, researchers' perceptions of costs, and researchers' perceptions of rewards. All three concepts were introduced to the researchers through a series of questions in the questionnaire.

Measures of Dependency

Degree of dependency on external sources was measured by three indicators: First, the number of external funding sources. This variable included the following categories: 1,2,3, and 4 or more external funding organizations. Second, the frequency of solicitation for additional or supplementary research funding during the past five years. The categories of this variable were: [1] less frequently than once every two years; [2] about once every two years; [3] about once a year; and [4] more frequently than once a year. Third, the average yearly amount of support needed to sustain research activities during the past five years. This variable ranged from $8,000 to $8 million, with a median of about $200,000. This variable included the following categories: 1) average yearly support of $100,000 or less; 2) $100,001-$249,000; 3) $250,000-$499,000; and 4) $500,000 and above.

The Spearman correlation between the total number of external organizations and the frequency of solicitation was 0.322 ($p<0.10$, two-tailed test, N=691), and between the total number of organizations and the average yearly support was 0.308 ($p<0.10$, two-tailed test, N=646.) There was no correlation between frequency of solicitation and average yearly support.

It should be noted that in some instances the measures of dependency were dichotomous in order to distinguish between low and high levels of dependency. The level of dependency on external organizations was perceived as high when 1)researchers were supported by one external funding organization only, or 2)when they solicited for additional support about once a year or more frequently than once a year, or 3)when researchers reported needing an average yearly support of $250,000 or more to sustain their research. The level of dependency on external organizations was perceived as low when 1)researchers were supported by more than one funding organization, or 2)when they solicited for

additional support about once every two years or less frequently than once every two years, or 3)when researchers reported needing less than $250,000 average yearly support.

Measures of Costs

Costs are perceived as the prices researchers pay for acquiring needed resources from external organizations. The concept of perceived costs was measured using two questions: first, the researchers were asked to evaluate the importance of a number of costs associated with collaboration with different funding sources using a four point scale of importance. Next, the respondents were asked to consider their experience with funding sources, and indicate which of the funding sources was best characterized by each of the costs. Asking the above questions, one could learn about the importance of each cost to the researcher, and find out which funding sources were perceived as offering the researchers most costs or least costs. The following eight items were regarded as costs:

1. The sponsor restricts the transfer of knowledge to colleagues.

2. The sponsor restricts the transfer of knowledge to the public at large.

3. The sponsor demands a proprietary interest in any new knowledge generated through the researcher's efforts.

4. The sponsor requires frequent or detailed progress reports.

5. The sponsor demands effort from the researcher in addition to the research itself (e.g., consulting services, attending conferences, etc.).

6. The sponsor demands some role in the design or execution of the research.

7. The sponsor applies pressure to obtain immediate or short term results.

8. The sponsor's willingness to fund projects in the researcher's specialty changes frequently or unpredictably.

Measures of Rewards

Rewards are perceived as the compensation offered to researchers by external sources for conducting scientific research. The concept of perceived rewards was measured by the same two questions as the concept of perceived costs. Six items were considered rewards:

1. The sponsor provides researchers with opportunities to advance their standing in their discipline.

2. The sponsor provides researchers with economic opportunities (e.g., patent rights, consulting opportunities, etc.).

3. The sponsor provides researchers with opportunities to achieve long-term research goals which extend beyond the scope of the research currently being funded.

4. The sponsor provides access to important "state of the art" technology not available at the current institution of the researcher.

5. The sponsor provides access to colleagues not employed at the researcher's institution.

6. The sponsor offers useful intellectual stimulation relevant to the researcher's work.

When referring to the hypotheses of the study, the phrases "overstatement of rewards" and "understatement of costs" are frequently used. Overstatement of rewards is a relative term which refers to researcher A's indication of more rewards, on the average, than the indication of rewards by researcher B. Estimation of rewards is measured by comparing the average number of rewards among researchers. Therefore, overstatement of rewards by the group of researchers "A" refers to a case where the average number of rewards indicated by members of group A is higher than the average number of rewards indicated by members of group B. Understatement of costs perceived by group X refers to an instance where the average number of costs indicated by members of group X is smaller than the average number of costs indicated by group Y. For example, in the first hypothesis I

stated that when facing a high level of dependency on external support, individuals will tend to overstate rewards and understate costs associated with collaboration with external organizations. In other words, researchers who are highly dependent on external support are expected to 1)indicate more rewards, on the average, than researchers with low dependency, and 2)mention less costs, on the average, than researchers who maintain a low level of dependency on outside support.

Control Variables

To control for factors which could affect the results of the data analyses, I examined the significance of three items on the dependent variable: academic discipline (engineers vs. bioscientists); type of institution (private vs. public schools); and academic status of the researcher (tenure vs. non-tenured professors). The assumptions about the intervening variables were that tenured professors would tend to be less dependent on external support than the non-tenured, because they might allow themselves to keep a low profile in the research endeavor once their tenure was granted. The tenured researchers might feel less pressure to prove their excellence to members of the scientific community compared to their junior colleagues.

In addition, tenured researchers have already established a network of relationships and contacts with key people in the funding organizations. This experience might ease the process of renewing contracts for additional support. The non-tenured professors would have to strive harder to convince sponsors that they deserve the support. The market for non-tenured researchers applying for external support seems to be more competitive and enduring than the market faced by tenured researchers.

No assumptions were made regarding the type of university (i.e., private vs. public institutions), and the academic disciplines of

the respondents (i.e., bioscience vs. engineering.) It was apparent that if no differences appear between the two types of institutions, or between disciplines, analyses of the data will be conducted for the whole sample, without controlling for these two factors. Of course, if only one of the controlled variables was found to affect the dependent variable, only that variable would be controlled for when testing the hypotheses.

Sample and Data

This study consists of a sample of 1,863 university professors in both engineering and bioscience departments, affiliated with five private and public doctoral universities located in geographical proximity to industrial regions.[2] Out of the 1,863 researchers to whom questionnaires were mailed, 187 had to be dropped from the sample because of different reasons such as being on sabbatical, moving to another university, and being inactive in conducting scientific research during the past couple of years. Forty-three percent of the researchers completed a mailed questionnaire from a sample of 1,676 eligible professors.

Results and Interpretation

Measuring the Perceptions of Costs and Rewards

The opinions of the researchers regarding the importance they attached to the costs and rewards were examined first. The degree of importance was measured on a 4-point scale from "of little or no importance" ("1") to "extremely important" ("4"). Since the importance of costs and rewards was a crucial concept in this study, only those items which were regarded by the respondents as extremely important were included in the analysis. Hence, costs and rewards which were not perceived by the researchers as important items (categories 1, 2, and 3) were omitted from the data analysis. Referring to all costs and rewards as if they were

equally important to all researchers would deceive the validity of the concept examined--the perceptions of researchers about costs and rewards.

Once the important costs were identified, responses to these items were added together to create an index of perceived costs. Similarly, when the important rewards were identified, an index of perceived rewards was constructed. My ultimate goal was to maximize the importance of costs and rewards so that the items would have the least amount of variance among the sub-samples. That is, I aimed to minimize the difference between engineers and bioscientists, between tenured and non-tenured researchers, and between researchers affiliated with private institutions and public universities. By picking those items which had the maximum importance to all the researchers, I could reduce the variance among the sub-groups and have a relatively homogenous group of respondents who assigned the same degree of importance to certain issues concerning the collaboration with external funding sources.

Tables 1 and 2 describe the items which were perceived by the respondents as the most important costs and rewards, respectively.

<Tables 1 and 2 about here>

An examination of Tables 1 and 2 reveals that more researchers attached a high degree of importance to costs than to rewards. Many more researchers were found to consider more costs as extremely important items than rewards. Almost the same number of researchers regarded the most important reward, having the opportunity to achieve long-term goals, as extremely important as regarded the third most important cost--the sponsor's demand for some role in the research--as extremely important (56% and 54% respectively.) Relatively few researchers described the second

and third most important rewards as "extremely important" ones.

However, when combining "important" and "extremely important" categories, the percentage of researchers who attached importance to the three rewards increased to 87%, 52% and 44% respectively (i.e., researchers who perceived these rewards as important or extremely important.) The researchers' view about rewards led me to restrict the number of items included in the index of rewards to three. Inclusion of the fourth important reward, intellectual stimulation offered by the sponsor, would have distorted the concept of importance, because only 11% of the researchers regarded this reward as an extremely important item, and an additional 20% of the respondents saw it as an important one (category "3".) Incorporating this reward into the index of rewards would have misrepresented the concept of importance of rewards as perceived by the researchers in this sample. Seventy percent of the respondents regarded this reward, exposure to intellectual stimulation, as "somewhat important" or "of little of no importance."

Relationship Between Dependency on External Funding Sources and the Perception of Costs and Rewards

To test the first hypothesis about the effects of a high level of dependency on the researchers' tendency to overstate rewards and understate costs, a regression analysis was conducted for each of the three measures of dependency (i.e., total number of organizations, frequency of solicitation, and average yearly support.) To control for bias resulting from the researchers' university affiliation, private or public universities, or from their discipline, bioscience or engineering, or from their academic status, tenured or non-tenured professors, these three factors were included in the regression equation.

The hypothesis was not supported by the data. Only one measure of dependency, "total number of external organizations," had a statistically significant effect on the perceptions of costs (Table 3.) Frequency of solicitation showed no statistically significant relationships with the perceptions of costs. The average yearly support needed to sustain research activities was found to be statistically significant related to perceived costs, but in the wrong direction. No significant results were found between any of the measures of dependency and perceived rewards. The discipline of the researcher showed a statistically significant relationship with the index of costs for each of the three measures of dependency. For each of the indicators of dependency, engineers indicated less costs, on the average, than bioscientists.

<Table 3 about here>

The variable, "total number of funding organizations," had significant effects on one's perceptions of costs (Table 3.) The greater the number of external organizations on which the respondent was dependent (i.e., the lower the dependency on each external source), the more the researcher tended to indicate higher costs associated with collaboration with external sources. The smaller the number of external organizations on which the researchers were dependent (i.e., the higher the dependency on each external source), the less the researchers tended to indicate costs associated with collaboration with external organizations.

The contribution of the control variables to the regression model was partial. The researcher's discipline showed a statistically significant effect on the perceptions of researchers regarding costs. To test whether there was a discipline effect on the relationship between levels of dependency and one's perceptions of the costs, an analysis of variance was conducted for the mean

score of the overall index of costs for each of the measures of dependency, by discipline. It was found that none of the measures of dependency showed statistically significant differences between bioscientists and engineers with regard to the mean score of the overall index of costs.

Another finding related to the control variable, although not statistically significant, was that tenured researchers tended to perceive more costs imposed by the sponsors than did their non-tenured colleagues (Table 3.)

What are the reasons which might have led to the rejection of this hypothesis? First, it might be that the measures of dependency used in this analysis were not sound. This explanation, though plausible, does not seem to me the reason for rejecting the hypothesis. The hypothesis was formulated in such a way so as to have six possibilities for support (using three measures of dependency with each dependent variable, perceived costs and perceived rewards.) Out of the six regression equations, four were not found to be statistically significant, one was significant in the expected direction, and the other one was significant, but not in the expected direction. If it was a problem of measuring dependency, I would expect that at least one measure would be found statistically significant for both dependent variables, or that more indicators will be related to one dependent variable. Hence, I surmised that the rejection of the hypothesis was not due to misspecification of the measures of dependency, but rather due to another reason.

A second plausible explanation for rejecting this hypothesis refers to the formulation of the hypothesis. It might be that the researchers' perceptions of costs and rewards differ from one funding source to another. That is, researchers might overstate rewards and understate costs associated with collaboration with one specific funding source, but not do so when referring to

another type of source. In the present hypothesis, I referred to costs and rewards which were characteristic of any funding source (i.e., federal agencies, private non-profit foundations, or private corporations). It might be that different results would have been achieved if the costs and rewards referred to private industry sponsors only.

There is still the impression among faculty members that collaboration between university and private industry involves more constraints on the researcher than collaboration with any other funding source. Some of the constraints seem to be in conflict with the interests and values prevailing in academia. If researchers perceived many costs associated with private corporations and few costs associated with non-profit sources, these differences in perceptions toward costs might have canceled each other out in the analysis of the whole data. Similarly, if researchers perceived few rewards associated with private corporations and many rewards associated with non-profit sources, these differences in perceptions toward rewards might have been wiped out in the analysis of the whole data.

Researchers' Perceptions of Rewards and Costs Associated with Collaboration with Private Corporations

Originally, I had planned to compare three types of researchers for testing the second hypothesis: researchers funded by the federal government only, researchers funded by private non-profit foundations only, and researchers supported solely by commercial organizations. But, since most of the researchers in this sample were supported by federal agencies, there were not enough researchers who reported receiving their main funding from other sources as well. Only 24 researchers indicated that they had received most of their support from commercial organizations. Therefore, I decided to include all researchers who received any kind of support from commercial organizations in the sample for

the test of this hypothesis. A similar situation existed in the case of researchers supported by private foundations only. There were few researchers who reported receiving their sole support from private non-profit foundations. Consequently, the analysis was based on comparing a group of researchers supported by commercial organizations to a group of researchers funded by federal agencies only. In this sub-sample, there were 384 researchers who were dependent on federal government support only, and 146 researchers who received support from private corporations.

To test the second hypothesis, a t-test was conducted for each of the three measures of dependency. Each time, the high level of dependency was controlled by using a dichotomous variable of dependency. Since the results of the data analysis for the first hypothesis did not show statistically significant effects of the control variables on the dependent variable (except for the academic discipline variable which did not show significant differences with respect to levels of dependency), there was no reason to investigate the contribution of these variables to the second hypothesis.

The t-test was used to examine the significance of differences in the mean score of the index of costs between researchers who received their support from commercial organizations and researchers who received funding from the federal government. It was hypothesized that there would be differences between the two groups of researchers: Researchers funded by commercial organizations would tend to indicate, on the average, less costs associated with collaboration with this source, than researchers supported by the federal government. With regard to perceived rewards, it was hypothesized that the differences between the two groups of researchers would be such that researchers funded by commercial organizations would tend to indicate, on the average, more rewards from receiving support from private corporations,

than researchers supported by the federal government.

When the total number of funding organizations was used as the measure of dependency, there were only seven respondents who were considered highly dependent researchers, and who reported receiving support from commercial organizations. In comparison, 81 researchers in the sample were funded by the federal government. Given this skewed sample, no data analysis could be conducted with this measure of dependency.

Table 4 presents the results of the t-test for perceived costs, and Table 5 presents the results for perceived rewards. For each table, two tests were conducted for each of the control variables: 1)frequency of solicitation for additional support, and 2)average yearly support needed to sustain research. The perceived costs and rewards used in this analysis refer to the items which were perceived by the respondents as associated with collaboration with commercial organizations only.

<Tables 4 and 5 about here>

The results of the data analyses mostly supported the hypothesis. The source of funding affected one's perceptions of costs and rewards when a high level of dependency was maintained. However, statistically significant differences at the 0.05 level were found only in the case of perceived rewards (Table 5). When dependency on external support was high, researchers supported by commercial organizations tended to indicate, on the average, more rewards and less costs associated with collaboration with private corporations. These findings were true when the two measures of dependency were applied to control for a high level of dependency: frequency of solicitation for additional support, and average yearly support needed to sustain research activities. With respect to perceived costs, the results were statistically significant at the 0.10 level (Table 4).

The source of funding proved to be a very significant variable in affecting the researchers' perceptions of rewards. Using the two measures of dependency, frequency of solicitation, and average yearly support, researchers supported by commercial organizations tended to indicate more rewards, on the average, than researchers supported by the federal government, when a high level of dependency was maintained. The data also showed that both groups of researchers (i.e., those supported by private industry, and those supported by the federal government) had relatively low mean scores of rewards associated with commercial organizations. The minimum value of the index of rewards was 0, and the maximum value was 3. As shown in Table 5, the mean score of the index of perceived rewards ranged from 0.27 (scored by researchers funded by the federal government) to 0.87 (scored by researchers supported by the private industry).

The findings of the second hypothesis were consistent in some respects with my speculation about the reasons behind the possible interpretations of the data for the first hypothesis. As was stated above, one of the possible reasons for the lack of support for the first hypothesis was that the reference to costs and rewards that were not related to a specific funding source might have been an inaccurate concept and too vague to measure. Researchers might relate more favorably to costs and rewards associated with source A, and less favorably to costs and rewards related to source B. Throwing together both sources in one category might wipe out the differences between them. The analysis of the data for the present hypothesis proved that when comparing the perceptions of researchers towards costs and rewards related to cooperation with commercial organizations, researchers who were funded by private industry tended to indicate, on the average, more rewards and less costs than researchers who were supported by the federal government.

One could claim that these results might be repeated if another funding source was targeted as the source to which the respondents attached costs and rewards. That is, we might find that when researchers refer to costs and rewards associated with collaboration with federal agencies, those individuals who are supported by this source would tend to indicate less costs and more rewards, on the average, than researchers who were funded by commercial organizations.

Though this counter-argument is basically reasonable, I would assert that significant results were not likely to be found in that direction for two reasons. First, neither federal agencies, nor private non-profit foundations have been described in the literature, nor were these sources perceived by the respondents in my study (see Table 6) as posing harsh constraints on the researcher compared to commercial organizations. With respect to rewards, both types of funding sources were acknowledged by the respondents as offering most rewards among all sources of funding (see Table 7). Second, commercial organizations were still perceived by members of the scientific community as posing most costs and least rewards among all sources of funding.

<Tables 6 and 7 about here>

The costs which were examined in this study were among the eight costs which most researchers had associated with collaboration with commercial organizations. The distribution of researchers who associated the four most important costs with collaboration with commercial organizations was as follows: 58%, 41%, 45% and 30%, respectively. That is, 58% of the respondents indicated that restrictions on transfer of knowledge to colleagues was most characteristic of commercial organizations, 41% of the respondents indicated that the sponsor's pressure to obtain immediate/short term results was best characterized by commercial organizations, etc. The percentages of respondents who attributed

these costs to the federal agencies were: 1%, 7%, 8% and 23% respectively. That is, only 1% of the respondents associated the restriction on the transfer of knowledge to colleagues as most characteristic of the federal government, etc. (Table 6.)

As shown in the table, the cost "sponsor's willingness to fund projects changes frequently" was perceived by more researchers as characteristic of the federal government, but as stated earlier, this item was perceived as the fourth most important item among all costs (see Table 1.) With respect to rewards, the first two rewards were perceived as mostly associated with the federal government, though the third reward in the list, "accessibility to 'state of the art' technology" was mostly associated with cooperation with private industry. But this reward was acknowledged only by less than 20% of the researchers as an extremely important reward in evaluating their working relationship with research sponsors (see Table 2). To conclude, the most important costs were associated with collaboration with commercial organizations, and the most important rewards were associated with the federal government.

The results of the data analysis with respect to rewards were as predicted. However, it is important to question why the results about perceived costs were not found to be statistically significant. A number of alternative explanations might decipher the puzzling results: The first explanation involves the issue of accessibility to the funding source. One might argue that the negative image developed by some researchers toward cooperation with commercial organizations was a result of the researchers' inexperience in working with these sources. That is, individuals who have not had any access to, or contacts with, commercial organizations, would be more likely to develop and maintain a negative image toward this sponsor than individuals who have worked with private industry sponsors and experienced good working relationships. Accordingly, it might be necessary to

examine the effects of accessibility and past experience of the researchers with this funding source on one's perceptions of the costs associated with collaboration with this sponsor.

Accessibility to commercial organizations was measured by responses to a question in which the researchers were asked to consider their own special area of interest, and indicate which of the funding sources "have indicated a particular willingness to support research" in their area. In the present analysis, I refer only to the willingness of commercial organizations to support research, and the variable was dichotomized so that 1=a positive indication of one or more commercial organizations; and 2=no indication of any commercial organization to support research.

In the second analysis, the independent variable, "past experience with the sponsor," was measured by the responses to the following question: "Please rate the following agencies with respect to how satisfactory, overall you think academic scientists in your area of research find their working (grant or contract) relationship with each." Again, in this analysis I refer to satisfaction from collaboration with commercial organizations only. This variable had four categories: 1=highly unsatisfactory; 2=generally unsatisfactory; 3=generally satisfactory; 4=highly satisfactory. The relationship between the two sets of variables: 1)perceived costs and accessibility, and 2)perceived costs and past experience were tested using regression analysis. Only results that showed statistical significance are reported for highly dependent researchers who were hypothesized to overstate rewards and understate costs (Tables 8, 9, and 10.) No reference was made to researchers who maintained a low level of dependency on external support. Each regression model was tested three times, once for each of the three measures of dependency: the total number of funding organizations, the frequency of solicitation for additional

support, and the average yearly support needed to sustain research.

<Tables 8, 9, and 10 about here>

The results of the data analyses with respect to accessibility to commercial organizations supported the above explanation. Accessibility to commercial organizations had a significant effect on one's perceptions of costs associated with collaboration with this funding source. This finding was true for each of the three measures of dependency which were used to control for a high level of dependency on external support (Tables 8, 9, and 10.) The negative relationship between accessibility to commercial organizations and perceived costs implies that researchers, to whom one or more commercial organizations had indicated willingness to support their research, perceived fewer costs related to cooperation with this source, than did researchers to whom commercial organizations did not indicate such a willingness. These results were highly significant, a fact which suggests that we should take the factor, "accessibility to funding sponsor," into account when examining the perceived costs toward a specific source.
Past experience with commercial organizations did not show statistically significant effects on perceived costs related to collaboration with this source. One's level of satisfaction from collaborating with commercial organizations was not related to the perceived costs associated with this source (at $p<0.05$.) At the 0.10 level, past experience had a negative impact on perceived costs, using frequency of solicitation and average yearly support as the measures of dependency. These results imply that the greater the satisfaction from working relationships with commercial organizations, the less the researcher perceived costs associated with this source. These findings are consistent with the explanation suggested above.

Another explanation for why the hypothesis was not supported with respect to perceived costs refers to the general feeling shared by many professors who have faced harsh times in raising research support in the last few years. Most researchers are aware of the constraints posed by commercial organizations, but still cannot allow themselves to turn down offers or opportunities coming from the private sector. Both groups of researchers, the one funded by the federal government only, and the other funded by commercial organizations, did not perceive many costs as extremely important in affecting the working relationships with the private industry. The mean score of the perceived index of costs ranged from 1.21 to 1.75, the minimum value of this index being 0 and maximum 4. Even those researchers who were not supported by private industry at the time the survey was administered, did not perceive many important costs associated with collaboration with private corporations. Is it a new wave of thinking which is a result of financial problems faced by most professors in academia, or is this finding related to another phenomenon? More research is needed to test this issue.

Finally, it would be important to examine whether or not we would come to the same conclusions if we were to repeat the above study, referring to perceived costs and rewards associated with non-commercial organizations. The existing literature in this area seems to suggest that, because university-industry research partnerships entails some disadvantages which are not embedded in the university-federal government or university-private foundation research relationships, one could assume that the phenomenon of overstatement of rewards and understatement of costs would be unique to the collaboration between university and commercial organizations. But is this really the case? Maybe researchers tend to overstate rewards and understate costs associated with any type of funding source once they are supported by that source. In this study, very few researchers associated costs with collaboration with the federal government,

the state/local governments, or the private foundations (see Table 6). Therefore, this explanation could not be tested in the framework of this study.

Implications of the Study

The implications of this study are presented from the points of view of three groups: 1)the funding sources; 2)the university; and 3)the academic researchers in engineering and bioscience departments. From the perspective of the funding sources, the first issue refers to the perceptions of university researchers of the rewards and costs associated with the funding organizations. Funding sources which strive to establish research partnerships with university researchers should be aware of the concerns which are highly important to researchers.

Funding sources need to recognize the fact that restrictions on the transfer of knowledge to colleagues is a cost which most researchers consider important. Therefore, if representatives of a certain funding source want to attract university researchers, they should examine whether collaboration with their organization entails this cost. If the restriction is present, I suggest that the policy be reviewed and changed.

In addition, policy-makers at both funding organizations and universities should know the kind of rewards which attract researchers, and the costs which antagonize them. The rewards which were perceived by the respondents as most important are listed below, in order from the most to least frequently mentioned: 1)opportunities to achieve long-term research goals which extend beyond the scope of the current research; 2)opportunities to advance the researcher's standing in his/her discipline; and 3)access to "state of the art" technology not available in the researcher's current institution. The costs which were perceived by the respondents as most important were:

1)the restriction of the transfer of knowledge to colleagues by the sponsor; 2)the pressure applied by the sponsor to obtain immediate or short term results; 3)the sponsor's demands to have a role in the design or execution of the research; and 4)the unpredictability of a sponsor's willingness to fund projects.

Policy-makers at funding organizations and universities should also know which rewards were not acknowledged as important by researchers sampled in this study. Only 17% of the researchers (N=117) indicated that "economic opportunities (e.g., patent rights, consulting opportunities, etc.)" were important to their relationship with funding sources. This is a relatively low percentage of respondents, considering the harsh times academic researchers face nowadays with respect to raising research support. A plausible explanation for this finding is that in recent years, we have witnessed a growing number of research partnerships between university professors and industrial corporations. This collaboration with the private industry has attracted university researchers mainly for the economic opportunities offered by these corporations. Nevertheless, academic researchers tend to reject this reason as a motive for their collaboration with the commercial organizations.

Another reward which did not receive great support from researchers in this sample was the intellectual stimulation offered by sponsors. Only 30% of the researchers (N=210) indicated that intellectual stimulation offered by sponsors was important to them. One would expect that more researchers would acknowledge this value in the academic realm. But it is very likely that these researchers expect to attain intellectual stimulation from colleagues in academic institutions, rather than from partners in funding sources.

Private corporations which seek to attract university researchers to cooperate with their organizations need to know that many

researchers, (at least those sampled in this study), attach importance to the opportunities available for long-term research goals. University professors are looking for a long-term rather than a short-term commitment. Hence, private corporations, which are mostly known as providers of short-term contracts are probably less attractive to university researchers than government agencies. The results of the data analysis imply that university-industry partnerships still carry negative connotations among academicians. To get away from this image, private industry needs to take steps to change this image. As long as the relationships between university and commercial organizations are portrayed in relatively dark colors, large numbers of university researchers will not be inclined to collaborate with this funding source.

Since the federal government provides most support to individuals in academic institutions, and is regarded as the preferred source, those who seek to establish relationships with university professors need to look into the factors which attract them to prefer the federal agencies over other sources. Level of financial support received from the federal government might be only one reason behind the overwhelming popularity of that source among university researchers. Nevertheless, other rewards which attract researchers to collaborate with federal agencies should be explored too. It might also be that because the collaboration with this source entails the smallest costs, researchers feel more inclined to prefer this type of source over others.

From the university administrator's point of view, a number of related issues are of concern. First, university officials need to recognize the costs paid by professors for collaborating with funding sources. There seems to be a conflict between the norms of academic research and those associating with commercial organizations. For example, the sponsor's demand for proprietary knowledge conflicts with the academic value of free dissemination

of knowledge. Issues of this kind need to be addressed and resolved before relationships are expanded, so that the price paid for establishing such relations will not exceed the benefits.

Second, university officials who are responsible for assisting researchers in establishing connections with funding sources need to be aware of the rewards which attract the researchers, and the costs which keep them away. Although in austere times, researchers might tend to collaborate with any funding source that offers support, it is up to university officials to strive to maximize the benefits of the researchers without hurting the academic ethos. One way policy-makers could deal with this issue is through the establishment of new regulations regarding the conducting of academic research.

Third, it seems that from the sample of respondents studied in this research, academic status (tenured or non-tenured faculty), type of university (private or public institution), and academic discipline (engineering or bioscience departments) did not affect the results about perceived costs and rewards, or about preference. This finding implies that this group of academic researchers can be viewed as one entity with respect to the issues discussed above.

With respect to academic researchers in the United States who are affiliated with departments of engineering and bioscience, they can be assured that they share similar views about external funding sources. General agreement is found among academics with regard to what they perceived as important (or not important) to their working relationships with funding sources. The researchers' concerns are not unique. There is a great commonality in perceptions among them, regardless of their academic discipline, or type of university (i.e., private vs. public.)

This consensus also applies to the way the researchers perceive the collaboration with commercial organizations. Engineers and bioscientists still perceive most costs associated with commercial organizations, rather than with any other source. Positive perceptions were reserved mostly for the collaboration with federal agencies, although in private conversations, researchers have criticized this source as becoming a bureaucratic monster which imposes an increasing number of restrictions on the academic and scientific endeavor.

Notes

1. Demands of sponsors to delay publication of research results, eliminate discussions about research in process with colleagues in the university, and offer the researcher a key position in the company which funds the research, are among the factors which contradict academic values, and create a conflict of interest for the researchers who are involved in such enterprise.

2. The importance of including universities that are surrounded by similar geographical areas derives from the assumption that industrial corporations and academic institutions tend to develop research partnerships if they are geographically close to each other.

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Table 1: Index of Perceived Costs

Variable	# of people attaching importance to the item*	N
Sponsor restricts transfer of knowledge to colleagues	479 (68.4%)	700
Sponsor applies pressure to obtain immediate or short term results	470 (67.7%)	694
Sponsor demands some role in the design or execution of the research	377 (54.1%)	697
Sponsor's willingness to fund projects changes frequently or unpredictably	312 (44.8%)	697

* Only the fourth category of importance scale ("extremely important") was used to create the index. Thus, over 68% of the respondents indicated that the restriction of sponsors to transfer knowledge to colleagues is an extremely important item (cost) in evaluating the working relationships with external sources.

Table 2: Index of Perceived Rewards

Variable	# of people attaching importance to the item*	N
Sponsor provides opportunities to achieve long-term research goals which extend beyond the scope of the current research	389 (55.7%)	698
Sponsor provides opportunities to advance the researcher's standing in his/her discipline	187 (27.1%)	691
Sponsor provides access to "state of the art" technology not available in the researcher's current institution	130 (18.8%)	690

* Only the fourth category of the importance scale ("extremely important") was used to create the index. Thus, over 55% of the respondents indicated that being offered the opportunity to achieve long-term research goals which extend beyond the scope of the current funded research is an extremely important item (reward) in evaluating the working relationships with external sources.

Table 3: Regression of Perception of Costs on Number of External Funding Sources, and Control Variables

	B Coefficient	Se B
Total number of funding orgs.	0.27***	0.06
Discipline	-0.44***	0.13
Type of institution	-0.07	0.12
Academic status	0.20	0.16
Intercept	1.35***	0.27
R^2	0.06	
N	566	

*** p<.001 (one-tailed test)

Total number of funding organizations includes four categories: 1, 2, 3, 4+ organizations. Category "4" refers to researchers who are dependent on 4 or more funding organizations, thus maintaining the lowest level of dependency on external support. Similar results were also found when the variable had two categories of low and high dependency.

Discipline categories are: 0=bioscience
1=engineering

Type of institution categories are: 0=public university
1=private university

Academic status categories are: 0=non-tenured professor
1=tenured professor

Table 4: Mean Scores of Researchers' Perceived Costs of Collaborating with Funding Sources, Controlling For Level of Dependency

Control Variable	Source of Funding	N	Mean	SD	T
Frequency of solicitation	Federal government	115	1.50	1.42	1.46+
	Commercial organizations	66	1.21	1.16	
Average yearly support	Federal government	130	1.75	1.39	1.37+
	Commercial organizations	49	1.45	1.31	

+ $p<0.10$ (one-tailed test)

Table 5: Mean Scores of Researchers' Perceived Rewards of Collaborating with Funding Sources, Controlling For Level of Dependency

Control Variable	Source of Funding	N	Mean	SD	T
Frequency of solicitation	Federal government	113	0.27	0.49	-5.51***
	Commercial organizations	61	0.87	0.76	
Average yearly support	Federal government	127	0.29	0.54	-3.50***
	Commercial organizations	43	0.74	0.79	

*** $p<0.001$ (one-tailed test)

Table 6: Funding Sources as Characterized by Researchers with respect to Costs - Frequency Distribution

Variable	Funding Source: Federal Gov.	State Gov.	Private Fdns.	Private Corps.	None*	Total
Sponsor restricts transfer of knowledge to colleagues	5 (1%)	2	5 (1%)	320 (58%)	224 (40%)	556 (100%)
Sponsor applies pressure to obtain immediate or short term results	36 (7%)	18 (3%)	11 (2%)	223 (41%)	251 (47%)	539 (100%)
Sponsor demands some role in the design or execution of the research	44 (8%)	13 (3%)	8 (1%)	236 (45%)	227 (43%)	528 (100%)
Sponsor's willingness to fund projects changes frequently or unpredictably	120 (23%)	26 (5%)	31 (6%)	158 (30%)	188 (36%)	523 (100%)

* This category refers to none of the funding sources, meaning that none of the funding sources was perceived as imposing a specific cost.

Note: The number of researchers who answered the above question was relatively small. This is probably due to the structure of the question which might have discouraged respondents to answer it.

Table 7: Funding Sources as Characterized by Researchers with respect to Rewards - Frequency Distribution

Variable	Funding Source: Federal Gov.	State Gov.	Private Fdns.	Private Corps.	None*	Total
Sponsor provides opportunities to achieve long-term research goals	392 (72%)	6 (1%)	45 (8%)	21 (4%)	83 (15%)	547 (100%)
Sponsor provides opportunities to advance researcher's stand in discipline	310 (58%)	2	25 (5%)	30 (6%)	165 (31%)	532 (100%)
Sponsor provides access to "state of the art" technology not available in current institution	115 (22%)	2	23 (5%)	174 (33%)	213 (40%)	527 (100%)

* This category refers to none of the funding sources, meaning that none of the funding sources was perceived as imposing a specific reward.

Table 8: Regression of Perception of Costs on Accessibility to Commercial Organizations, Using Total Number of Funding Organizations as the Measure of Dependency

	B Coefficient	Se B
Accessibility to commercial organizations	-0.81**	0.30
Intercept	2.72***	0.53
R^2	0.07	
N	97	

** p<0.01 (one-tailed test)
*** p<0.001 (one-tailed test)

Accessibility to commercial organizations is a dichotomized variable with the following categories: 1=a commercial organization indicated a willingness to support research; 2=a commercial organization did not indicate a particular willingness to support research.

Table 9: Regression of Perception of Costs on Accessibility to Commercial Sponsors, Using Frequency of Solicitation as the Measure of Dependency

	B Coefficient	Se B
Accessibility to commercial orgs.	-0.75***	0.18
Intercept	2.49***	0.25
R^2	0.07	
N	247	

*** $p<0.001$ (one-tailed test)

For explanation of "accessibility to commercial organizations", see Table 8.

Table 10: Regression of Perception of Costs on Accessibility to Commercial Sponsors, Using Average Yearly Support as the Measure of Dependency

	B Coefficient	Se B
Accessibility to commercial orgs.	-0.51**	0.19
Intercept	2.37***	0.27
R^2	0.03	
N	229	

** p<0.01 (one-tailed test)
*** p<0.001 (one-tailed test)

For explanation of "accessibility to commercial organizations", see Table 8.